**<u>Amendments to the Specification</u>:**

*Please replace the heading at page 13, line 10, with the following replacement heading:*

**<u>Optical Sensing Of Actuator Movement ~~And~~ In XY Plane</u>**

*Please replace the paragraph starting at page 1, line 1, with replacement paragraph as follows:*

<u>Cross-Reference to Related Applications</u>

This application is a continuation<u>-in-part of</u> application ~~of~~ U.S. Serial No. 09/855,960, filed May 15, 2001, now U.S. Patent No. 6,530,268, which is a continuation<u>-in-part of</u> application ~~of~~ U.S. Serial No. 09/803,268, filed March 9, 2001, each of which is expressly incorporated by reference herein in its entirety.

*Please replace the paragraph starting at page 1, line 15, with replacement paragraph as follows:*

A scanning probe microscope operates by providing relative scanning movement between a measuring probe assembly having a sharp stylus and a sample surface while measuring one or more properties of the surface. The examples shown in FIGURES 1A and 1B are atomic force microscopes <u>10 and 11</u> respectively ("AFMs") where a measuring probe assembly 12 includes a sharp tip or stylus 14 attached to a flexible cantilever 16. Commonly, an actuator such as a piezoelectric tube (often referred to herein as a "piezo tube") is used to generate relative motion between the measuring probe 12 and the sample surface. A piezoelectric tube is a device that moves in one or more directions when voltages are applied to electrodes disposed inside and outside the tube (29 in FIGURE 1C).

*Please replace the paragraph starting at page 2, line 12, with replacement paragraph as*

*follows:*

One of the continuing concerns with these devices is how to improve their accuracy. Since these microscopes 10, 11 often measure surface characteristics on the order of Ångstroms, positioning the sample and probe with respect to each other is critical. Referring to FIGURE 1C, as implemented in the arrangement of FIGURE 1A, when an appropriate voltage ($V_x$ or $V_y$) is applied to electrodes 29 disposed on the upper portion 30 of piezoelectric tube actuator 18, called an X and Y axis translating section or more commonly an "X-Y tube," the upper portion may bend in two axes, the X and Y axes as shown. When a voltage ($V_z$) is applied across electrodes 29 in the lower portion 32 of tube 18, called a Z axis translating section or more commonly a "Z-tube," the lower portion extends or retracts, generally vertically. In this manner, portions 30, 32 and the probe (or sample) can be steered left or right, forward or backward and up and down. This arrangement provides three degrees of freedom of motion. For the arrangement illustrated in FIGURE 1A, with one end fixed to a microscope frame (for example, 34 in FIGURE 1D), the free end of tube 18 can be moved in three orthogonal directions with relation to the sample 20. In addition, with the X-Y tube 30 on top of the Z-tube 32 (i.e., furtherest from probe assembly 12), maximum X-Y range is realized.

*Please replace the paragraph starting at page 5, line 23, with replacement paragraph as follows:*

According to yet another aspect of this embodiment, the reference structure is fixed to the multiple bar linkage to deflect the multiple bar linkage in the X and Y directions in response to X and Y deflections of the x and y-axis translating stage. The multiple bar ~~multi-bar~~ linkage further includes a first mirror fixed to a least one of the links of the multiple bar ~~multi-bar~~ linkage, and a second mirror fixed to another of the links of the multiple bar ~~multi-bar~~ linkage.

*Please replace the paragraph starting at page 9, line 16, with replacement paragraph as follows:*

Referring initially to FIGURE 2, a scanning probe microscope (SPM) 100 is shown. The microscope includes a chassis including a support 102 to which a probe assembly 104 is attached. Probe assembly 104 is configured to interact with a sample 106. More particularly, probe assembly 104~~102~~ is kept stationary while sample 106 is translated, preferably in raster scan fashion, relative thereto to image or otherwise collect data pertaining to the sample. An actuator assembly 108 includes an actuator 110 for translating the sample 106, and a reference assembly 112 defining, among other structure, an elongate reference structure 114 that surrounds actuator 110. Reference structure 114 is tubular and has a longitudinal axis that is generally collinear with the longitudinal axis of actuator 110. Actuator 110 is preferably piezoelectric or electrostrictive, and may be a tube actuator or another type of actuator conventional in the art of nanopositioning systems. Actuator 110 is fixed to a mount 116 which is also coupled to the chassis of the microscope.

*Please replace the paragraph starting at page 9, line 29, with replacement paragraph as follows:*

Probe assembly 104 is fixed to support 102 and includes a cantilever 118 having a stylus (i.e., tip) 120 either attached thereto or formed integrally therewith. During operation, the surface of sample 106 is scanned beneath fixed stylus 120 to determine characteristics (for example, surface topography) of sample 106. The scanning operation is provided by actuator 110, which is driven by program-controlled signals (e.g., appropriate voltages) to cause the actuator 110 to move laterally in two dimensions, as well as to extend and retract in this embodiment. This movement of the actuator is transmitted to sample 106 which is mounted on a sample mount 122 that translates in conjunction with actuator 110. For example, actuator 110 can move sample 106 toward or away from tip 120 in a vertical direction in response to closed loop signals derived from a sensor 121 (as shown in Efigure 4), in conventional fashion as described below.

*Please replace the paragraph starting at page 10, line 25, with replacement paragraph as follows:*

As noted, actuator 110 preferably translates sample 106 in three orthogonal directions under program control. This is preferably implemented as shown in the Figures where actuator 110 includes an X-Y tube section 126 coupled to the chassis and a Z tube section 124 coupled to X-Y tube 126. Z tube section 124 has a free end coupled to sample 106, preferably positioned on top of X-Y tube 126 to maximize the range of X-Y motion provided by X-Y tube 126. As illustrated in Fig. 2, the two tube sections 124, 126 of piezoelectric actuator 110 are coupled together end-to-end proximate to a circular collar 128 that extends around and is affixed to the actuator sections.

*Please replace the paragraph starting at page 11, line 22, with replacement paragraph as follows:*

To realize this minimization of parasitic movement of actuator 110, flexure 132 is also coupled to fixed reference structure 114. Flexure 132 is preferably a parallelogram flexure comprising a four-bar linkage that is adapted to translate so that its opposed vertical links 150, 152 and 154, 156 remain generally orthogonal to the X-Y plane in response to a force, and therefore displacement, transmitted in the vertical or Z direction by bar 134. This movement of flexure 132 is rotational about points 158, 160, 162, 164 thereof.

*Please replace the paragraph starting at page 12, line 12, with replacement paragraph as follows:*

With more specific reference to Figures 2-4, a second source 164 of electro-magnetic radiation (e.g., a laser) which is part of an optical measuring device 163 is used in an apparatus to measure Z-movement of section 124. Source 164 is mounted so as to direct a beam of light "L" generally vertically (i.e., orthogonal to the sample surface) through focusing lens 166 and on to a mirror 168 of optical measuring device 163. Mirror 168 directs the beam towards the multi-bar linkage, also referred to as flexure 132 which, again, is mounted on reference structure 114, and which supports sample 106. A reflecting surface, such as a mirror 170 is mounted on one of the links 152 of flexure 132 and directs the beam towards the second mirror 172 in a corner-cube arrangement such that flexure 132 comprises part of optical measuring device 163 on another of the links of flexure 132 which thereafter

directs the beam towards yet another reflecting surface 174. Reflecting surface 174 (e.g., a mirror) then directs the reflected beam towards a detector 178 to measure the movement of the sample in the vertical, or Z, direction. Again, because the flexible bar 134 only transmits forces in the vertical direction, parasitic movement of the Z section 124 of actuator 110 is not transmitted to flexure 132 and thus such movement does not affect movement measured by the optical measuring device 163. Preferably, a cylindrical lens 176 is disposed intermediate mirror 174 and detector 178 (or it can be located at any point between laser 119 and detector 178 as desired) to maintain sufficient signal and thus enhance precision.

*Please replace the paragraph starting at page 13, line 28, with replacement paragraph as follows:*

The two tube sections 124, 126 of piezoelectric actuator 110 are coupled together end-to-end proximate to a circular collar 128 that extends around and is affixed to the actuator sections. Actuator assembly 110 is preferably coupled to ~~frame~~ support 102 at its lower end, for example, using collar mount 116 shown in Figures 5 and 6. In this embodiment, elongate reference structure 182 of reference assembly 180 extends around at least the Z tube 124 of actuator 110, and is fixed to the collar 128. Collar 128, in turn, is fixed to actuator 110 at or near the junction of the upper and lower actuator sections 124, 126. When X-Y tube is driven under program control, it deflects in a direction generally perpendicular to the longitudinal axis of actuator 110. Because collar 128, and reference structure 182 are fixed to the actuator near the top of the X-Y tube, they also deflect laterally. Again, the X-Y tube is preferably placed furthest from the structure it is translating (in this case sample holder 122 and sample 106) so as to maximize X-Y range of motion (i.e., scanning).

*Please replace the paragraph starting at page 14, line 18, with replacement paragraph as follows:*

In the operation of this embodiment, an optical measuring apparatus 190 measures movement of sample 106 in the X and/or Y directions (e.g., the XY plane) in response to voltage signals applied to X-Y actuator 126. Optical measuring apparatus 190 includes a

light source 192, an objective 194 fixed to reference structure 182, and a position sensor 196. Movement of objective 194 depends on movement of reference structure 182, while light source 192 and position sensor 196 are stationary. Objective 194 is preferably located between light source 192 and position sensor 196. ~~Alternatively, light source 192 may be coupled to reference structure 182, while objective 196 is stationary.~~